CLAIMS

What is claimed is:

1. A fuel processing reactor comprising:

a vessel comprising a heat exchange fluid inlet and a heat exchange fluid outlet;

a shell disposed within the vessel, at least a portion of the shell being spaced apart from the interior wall of the vessel, the shell comprising:

a first process gas inlet and a first process gas outlet, each extending through the vessel and fluidly isolated therefrom, and

a second process gas inlet and a second process gas outlet, each extending through the vessel and fluidly isolated therefrom;

a shift catalyst bed disposed in the shell and in fluid communication with the first process gas inlet and first process gas outlet;

a second bed disposed in the shell downstream of the shift catalyst bed and in fluid communication with the second process gas inlet and second process gas outlet; and

a plurality of tubes disposed within the shell and fixed thereto, each of the tubes extending through at least one of the shift catalyst bed and second bed, wherein the tubes and the space between the shell and the interior wall of the vessel form passageways for fluid flow between the heat exchange fluid inlet and heat exchange fluid outlet.

2. The reactor of claim 1 wherein the vessel further comprises removeably attachable end plates.

3. The reactor of claim 1 wherein the vessel is insulated.

4. The reactor of claim 1 wherein the fluid inlet is connectable to a cathode exhaust manifold of a fuel cell stack for supplying cathode exhaust to the vessel as a heat exchange fluid.

5. The reactor of claim 1 wherein the shell is disposed concentrically within the vessel.

6. The reactor of claim 5 wherein the space between shell and the interior wall of the vessel forms an annular passageway.

7. The reactor of claim 1, further comprising a plenum located in the shell between the shift catalyst bed and the second bed, and fluidly isolated therefrom, wherein a portion of the tubes extend from one end of the shell to the plenum through the shift catalyst bed, and another portion of the tubes extend from the other end of the shell to the plenum through the second bed.

8. The reactor of claim 1 wherein the shift catalyst bed comprises an upstream low-temperature shift catalyst bed and a downstream high-temperature shift catalyst bed.

9. The reactor of claim 8 wherein the portion of the tubes extending through the high-temperature shift catalyst bed comprise heat exchange elements.

10. The reactor of claim 9 wherein the heat exchange elements comprise swirlers.

11. The reactor of claim 1 wherein the second bed comprises a hydrodesulfurization catalyst bed.

12. The reactor of claim 11 wherein the second bed further comprises a metal oxide bed in fluid communication with the hydrodesulfurization catalyst bed.

13. The reactor of claim 12 wherein the second bed further comprises a sulfur polisher bed in fluid communication with the metal oxide bed.

14. The reactor of claim 1 wherein the second bed comprises a metal oxide bed.

15. The reactor of claim 14 wherein the second bed further comprises a sulfur polisher bed in fluid communication with the metal oxide bed.

16. A fuel processing reactor comprising:

a vessel comprising a heat exchange fluid inlet and a heat exchange fluid outlet;

a first shell disposed within the vessel, at least a portion of the first shell being spaced apart from the interior wall of the vessel, the first shell comprising a first process gas inlet and a first process gas outlet, each extending through the vessel and fluidly isolated therefrom;

a shift catalyst bed disposed in the first shell and in fluid communication with the process gas inlet and process gas outlet;

a first plurality of tubes disposed within the first shell and fixed thereto, each of the tubes extending through the shift catalyst bed;

a second shell disposed within the vessel, at least a portion of the second shell being spaced apart from the interior wall of the vessel, the second shell comprising a second process gas inlet and a second process gas outlet, each extending through the vessel and fluidly isolated therefrom;

a second bed disposed in the second shell and in fluid communication with the second process gas inlet and second process gas outlet; and

a second plurality of tubes disposed within the second shell and fixed thereto, each of the tubes extending through the second bed, wherein the tubes, and the spaces between the first and second shells and the interior wall of the vessel, form passageways for fluid flow between the heat exchange fluid inlet and heat exchange fluid outlet.

17. The reactor of claim 16 wherein the vessel further comprises removeably attachable end plates.

18. The reactor of claim 16 wherein the vessel is insulated.

19. The reactor of claim 16 wherein the fluid inlet is connectable to a cathode exhaust manifold of a fuel cell stack for supplying cathode exhaust to the vessel as a heat exchange fluid.

20. The reactor of claim 16 wherein the first shell is disposed concentrically within the vessel.

21. The reactor of claim 20 wherein the space between first shell and the interior wall of the vessel forms an annular passageway.

22. The reactor of claim 16 wherein the second shell is disposed concentrically within the vessel.

23. The reactor of claim 22 wherein the space between second shell and the interior wall of the vessel forms an annular passageway.

24. The reactor of claim 16 wherein the shift catalyst bed comprises an upstream low-temperature shift catalyst bed and a downstream high-temperature shift catalyst bed.

25. The reactor of claim 24 wherein the portion of the tubes extending through the high-temperature shift catalyst bed comprise heat exchange elements.

26. The reactor of claim 25 wherein the heat exchange elements comprise swirlers.

27. The reactor of claim 16 wherein the second bed comprises a hydrodesulfurization catalyst bed.

28. The reactor of claim 27 wherein the second bed further comprises a metal oxide bed in fluid communication with the hydrodesulfurization catalyst bed.

29. The reactor of claim 28 wherein the second bed further comprises a sulfur polisher bed in fluid communication with the metal oxide bed.

30. The reactor of claim 16 wherein the second bed comprises a metal oxide bed.

31. The reactor of claim 30 wherein the second bed further comprises a sulfur polisher bed in fluid communication with the metal oxide bed.

32. A fuel processing reactor comprising:

a vessel comprising a heat exchange fluid inlet and a heat exchange fluid outlet;

a shell disposed within the vessel, at least a portion of the shell being spaced apart from the vessel, the shell comprising a process gas inlet and a process gas outlet, each extending through the vessel and fluidly isolated therefrom;

a shift catalyst bed disposed in the shell and in fluid communication with the process gas inlet and process gas outlet; and

a plurality of tubes disposed within the shell and fixed thereto, each of the tubes extending through the shift catalyst bed, wherein the tubes and the space between the shell and the interior wall of the vessel form passageways for fluid flow between the heat exchange fluid inlet and heat exchange fluid outlet.

33. The reactor of claim 32 wherein the vessel further comprises a removeably attachable end plate.

34. The reactor of claim 32 wherein the vessel is insulated.

35. The reactor of claim 32 wherein the fluid inlet is connectable to a cathode exhaust manifold of a fuel cell stack for supplying cathode exhaust to the vessel as a heat exchange fluid.

36. The reactor of claim 32 wherein the shell is disposed concentrically within the vessel.

37. The reactor of claim 36 wherein the space between shell and the interior wall of the vessel forms an annular passageway.

38. The reactor of claim 32, further comprising a metal oxide bed disposed in the shell between the shift catalyst bed and the process gas inlet.

39. The reactor of claim 38 wherein the metal oxide bed comprises zinc oxide.

40. The reactor of claim 38, further comprising a sulfur polisher bed disposed in the shell between the metal oxide bed and the low-temperature shift catalyst bed.

41. The reactor of claim 32 wherein the shift catalyst bed comprises an upstream low-temperature catalyst bed and a downstream high-temperature shift catalyst bed.

42. The reactor of claim 41, further comprising a metal oxide bed disposed in the shell between the low-temperature shift catalyst bed and the high-temperature shift catalyst bed.

43. The reactor of claim 42, further comprising a sulfur polisher bed disposed in the shell between the metal oxide bed and the low-temperature shift catalyst bed.